WAVETEK

Heavy Duty Series Digital Multimeters

OR Beckman

HD100, HD110, HD110T & HD130B

Operator's Manual

WARNINGS AND PRECAUTIONS

PLEASE READ SECTION II – *SAFETY INFORMATION,* AND SECTION IV – *OPERATING INSTRUCTIONS,* REGARDING "WARNINGS AND PRECAUTIONS"

Exceeding the maximum limits of this instrument is DANGEROUS.

Exceeding these limits will expose you to physical injury or even death and will almost certainly damage your instrument. Even low-level voltages and currents are capable of causing serious injury or even death.

Please do not use this or any piece of test equipment without proper training. Individual functions and ranges have different overload limits. It is VERY IMPORTANT that you make yourself aware of these overload limits. Check the specifications in Section IV for specific overload limits.

Heavy Duty Series Digital Multimeters

(HD100, HD110, HD110T & HD130B)

Operator's Manual

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Warranty

One Year Limited Warranty

Heavy Duty Series Digital Multimeters are warranted against any defects of material or workmanship within a period of one (1) year following the date of purchase of the multimeter by the original purchaser. This warranty is extended by Wavetek Corporation (manufacturer), only to the original purchaser or original user of the multimeter.

In the USA any multimeter claimed to be defective during the warranty period should be returned to Wavetek's Factory Service Center. Follow the shipping instructions on page 34 and in Section VIII. For warranty repair outside the USA contact your local Wavetek dealer or distributor where your multimeter was purchased, or return it to Wavetek's Factory Service Center. Refer to Section VIII for the appropriate address.

In event of replacement with a new or reconditioned model, the replacement unit will continue the warranty period of the original multimeter.

ANY IMPLIED WARRANTIES ARISING OUT OF THE SALE OF A HEAVY DUTY SERIES MULTIMETER, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE ABOVE-STATED ONE (1) YEAR PERIOD. MANUFACTURER SHALL NOT BE LIABLE FOR LOSS OF USE OF THE MULTIMETER OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, OR ECONOMIC LOSS OR FOR ANY CLAIM OR CLAIMS FOR SUCH DAMAGE, EXPENSES OR ECONOMIC LOSS.

Some states do not allow limitations on how long implied warranties last or the exclusion or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Wavetek Corporation
Instruments Division

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Section I Introduction

Series 100 Heavy Duty Digital Multimeters are portable, rugged, hand-held 3½-digit multimeters designed for the engineer, technician, or hobbyist who demands an accurate, reliable, durable instrument that is always ready for use. Equipped with seven functions and 29 ranges, each test position is selected by simply turning the selector switch. Small enough to fit in most attaché cases and equipped with a multi-position tilt stand, these instruments are equally suited for design and engineering, production testing, field servicing, and industrial maintenance applications.

Additionally, the Heavy Duty Series offers two uncommon, yet particularly useful features. With Insta-Ohms, circuit shorts can be traced and other continuity checks can be made more quickly and easily than ever before with a digital multimeter! It also can be used for troubleshooting small-value capacitors. The heavy duty case is tough—to sustain accidental drops and is sealed with O-rings to exclude dirt, oil, and water.

Standard Features

All of the following features are standard for the Heavy Duty Series:

Superior Reliability

To ensure reliability, Wavetek designed a custom CMOS large-scale integrated circuit to eliminate most components. All active multimeter functions are performed by this integrated circuit, reducing the number of parts in each instrument. Reliability is also enhanced by 100% burn-in of each multimeter and complete factory test of every function and range.

Guaranteed Long-Term Accuracy

Specified accuracies are guaranteed for one (1) full year. Long-term accuracy is assured by the use of an extremely stable band-gap reference element and precision thin-film resistor networks.

Ruggedness

Heavy Duty Series Multimeters are designed for years of trouble-free operation under heavy duty use. The instruments can take accidental falls and come up working—and still meet specified accuracies. The display and single rotary switch are recessed and sealed to prevent damage while in a tool box or on the job. The case is designed to keep out dirt, dust, liquids, and other contaminants that can cause malfunctions in other multimeters.

Waterproof

The meter case has been totally O-ring sealed, including the range selection knob and the four screws that access the circuitry. The display window is gasketed and ultrasonically sealed in the case for a tight, waterproof seal. The input terminal jacks are O-ring sealed and water-tight.

Overload and Transient Protection

All inputs are protected against *continuous* overload conditions that may result from the measurement of unknown signals or from operator error, up to the limits of each function's stated input protection (see *Specifications*). In addition, all voltages and resistance ranges are protected against voltage transients up to 6kV, ten micro-seconds duration. Current ranges are protected by 600V fuses of either 2 amp or 15 amp rating. The ten amp current input is protected to a fault limit of 100,000 amperes when the factory recommended fuse is installed.

Ease of Use

Human engineered in every way to make the instruments easy to use, a single switch turns on power, and selects both function and the desired range. The liquid-crystal display (LCD) is easy to read both indoors and outdoors - even in direct sunlight.

In-Circuit Resistance Measurements

All resistance ranges are low-power ohms which allow accurate measurements on in-circuit resistance. Because test voltages are held to less than 250mV, accurate measurements may be made even in circuits where resistors are directly shunted by typical silicone diodes and transistors.

Diode Test Function

A special diode test function allows accurate measurements of forward voltage drops across diodes and transistor junction, even in circuits where semiconductors are shunted directly by resistors.

Battery Life

One standard 9-volt transistor battery provides up to 2,000 hours of continuous instrument operation. Under typical use, a battery should last two years.

Low Battery Indicator

The decimal point begins to blink when approximately 200 hours of battery life remains.

Versatility

Perfect for field, lab, or home use. Small, lightweight, and completely portable. It has a handy tilt stand for easy positioning and antiskid pads to keep it in place.

Complete and Ready for Use

Instruments are shipped with battery and fuse installed, ready to use. Also, included with each instrument is a spare 2 amp fuse, TL-245 Probe Set.

Special Features

HD100

The HD100 has the features described previously, excluding the Insta-Ohms Quick Continuity test function and ten ampere current ranges. It has an accuracy of ±0.25% of reading in DC volts.

HD110

The HD110 has all of the features of the HD100 plus the Insta-Ohms Quick Continuity test function, audible continuity indicator, and ten ampere current ranges. It has an accuracy of ± 0.25% of reading in DC volts.

HD110T

The HD110T has all the standard features and performance of the HD110, except the audible continuity beeper. In addition, the HD110T offers a built-in temperature measurement function which uses a standard Type K thermocouple to read temperature in either Fahrenheit or Celsius. It has an accuracy of ± 0.25% of reading in DC volts.

HD130B

The HD130B has all the features of the HD100 plus the Insta-Ohms Quick Continuity test function, and ten ampere current ranges. It has an accuracy of ± 0.1% of reading in DC volts and the capability of measuring the True RMS value of AC voltage and current.

NOTE

The symbol on the front panel of the multimeter is an international symbol meaning "REFER TO OPERATING INTRUCTIONS." Warnings and precautions to avoid personal injury and multimeter damage are listed in Section IV.

WARNING

High voltages can be lethal. Use extreme caution when working with and measuring high-voltage sources. High voltage transients may occur in nearly all defective electronic equipment.

This manual contains important safety information and warnings which must be followed in order to ensure safe operation and to protect the user from serious injury or death.

Section II Safety Information

This section of the manual describes the various operating modes on the Multimeter as well as a summary of warnings and precautions.

WARNINGS!

When "W" is used in this manual it advises the user of a hazard that could result in serious injury or even death. The "W" refers the user to the "WARNINGS" below and in the operating instructions in Section IV.

PRECAUTIONS!

When "P" is used in this manual it advises the user of a hazard that could cause damage or malfunction in the instrument. The "P" refers the user to the "PRECAUTIONS" below and in the operating instructions in Section IV.

"W"
"P"

WARNINGS & PRECAUTIONS

1. **Do not attempt to measure voltages or currents that may exceed the ratings marked on the Function/Range Switch or terminal overlays.**
2. **Use extreme caution when working near high voltage sources. This includes any voltage measurements requiring the use of the two highest VAC or VDC ranges.**
3. **To avoid electrical shock hazard and/or damage to the multimeter, do not measure voltages that might exceed the maximum voltage rating above earth ground.**
4. **Operator injury or damage to the multimeter may occur during current measurements if the fuse blows in a circuit which exhibits an open circuit voltage greater than 600 volts.**
5. **Before each use of the multimeter, inspect test leads, connectors, and probes for cracks or breaks in the insulation. If any defects are found, replace item immediately.**
6. **To avoid electrical shock hazard, do not touch test leads, tips, or the circuit being tested while power is applied to the circuit being measured.**

"P" **PRECAUTIONS**

1. **Exceeding the maximum input overload limits can damage the multimeter.**
2. **When measuring current, check that the multimeter is connected in series with the load in which the current is to be measured. NEVER connect the multimeter ACROSS a voltage source. To do so can result in either blowing the overload protection fuse or damaging the device being tested.**
3. **Always remove the temperature probe from the HD110T before using any other functions.**

Overload Indication

"P" **PRECAUTION!**

Range overload is indicated by "OL" in display. This is normal in the OHMS range when the leads are not connected to anything. In all other situations, the user must take immediate steps to remove the cause of the overload condition from the instrument.

The multimeters are equipped with automatic overload indication. This means that whenever an input signal is larger than the range selected, an overload symbol (OL) will appear in the Digital Display, see Figure 6. This feature allows the user to test devices with unknown circuitry where an overload condition might exist but would not exceed the capability of the multimeter.

Voltage Measurements

"W" "P" **CRT SERVICE SAFETY REMINDER: A POTENTIAL DANGER TO YOU AND YOUR METER EXISTS WHEN MEASURING VOLTAGES IN THE HORIZONTAL OUTPUT AND DAMPER STAGES OF CRT EQUIPMENT. THIS DANGER IS CAUSED BY THE HIGH VOLTAGE TRANSIENTS (GREATER THAN 6,000 VOLTS) THAT OCCUR IN THESE CIRCUITS. PLEASE REFER TO YOUR CRT SERVICE MANUAL FOR PROPER SERVICING INSTRUCTIONS.**

Section III Preparation for Use

This section describes the following: unpacking and inspection, installation, controls, indicators, connectors, and initial checkout procedure.

Unpacking and Inspection

Remove the multimeter from the shipping container. The box should contain the following:

1. Multimeter
2. TL-245 Probe Set (one black, one red)
3. Nine-volt battery (installed)
4. Two, 2A fuses (one installed and one spare inside the case) and one 15A fuse (installed, all except HD100). To gain access to inside of instrument, see Section VI.

Account for and inspect all of these items. If any of the items are damaged or missing, immediately return the complete package to the place of purchase for an exchange.

NOTE

Retain the shipping container for use if instrument must be returned for exchange or repair.

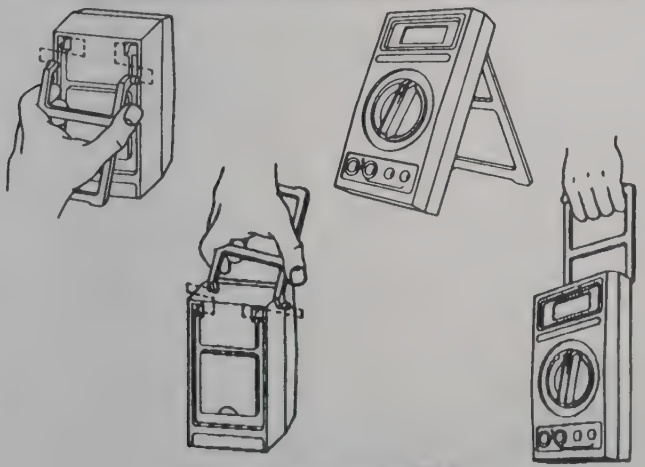


Figure 1. Positioning the Tilt Stand

Installation

The multimeter is shipped ready for use. The only action required by the user is to place the tilt stand in the desired position. Figure 1 shows the positions that the tilt stand may be placed in. The tilt stand is moved from one position to another by squeezing the two sides of the stand together and then reinserting the tips in the desired positions.

Multimeter Familiarization

We STRONGLY RECOMMEND that the user become familiar with the controls, indicators, and connectors of the Multimeter, shown and described in Figure 2, before operating the device.

1. Digital Display—A shock-mounted 3½-digit LCD readout (max. reading 1999) with automatic decimal point placement, automatic polarity indication, over-range indication, low battery indication (blinking decimal point), and the Insta-Ohm Quick Continuity Indicator (Ω) indicates measured input value in volts, amperes, or ohms as selected by the Function/Range Switch.

2. Function/Range Switch—This switch turns the instrument off and on and selects the function and range. Six functions can be selected by directing the pointer on the center bar to: VDC, VAC, DCA, ACA, Ω(ohms), or Diode Test. The VDC function provides five ranges from 200mVDC to 1500VDC. The VAC function provides five ranges from 200mV to 1000VRMS AC. The DCA and ACA functions each provide five ranges of current measurements from 200µA to 2A full-scale on the HD100, and six ranges of current measurements from 200µA to 10A full-scale on the HD110, HD110T, and HD130B.

3. Diode Test Function—Used for checking diodes and other semiconductor junctions.

4. A Input Connector (White)—Banana jack connector for current measurements up to 2 amps. The multimeter is protected by a fuse against inputs over 2 amperes.

5. COM Input Connector (Black)—Banana jack connector used as the common or low input for all measurements.

6. V-Ω Input Connector (Red)—Banana jack connector used as the high input for all voltage and resistance measurements.

7. 10A Input Connector (White), HD110, HD110T, and HD130B only—Banana jack connector used for current measurements up to 10A. The multimeter is protected by a fuse against inputs over 10 amperes.

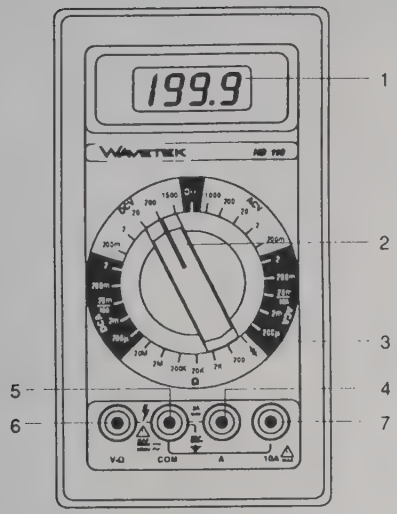


Figure 2: Operating Controls, Indicators and Connections

Initial Checkout

Before placing the Multimeter into use, a simple checkout procedure will ensure that the device is working properly. The only equipment required is the test leads.

1. Be certain that battery and fuse are installed properly, see Section VI.
2. Connect the red test lead to the V-Ω Input Connector and the black test lead to the COM Input Connector.
3. Place the Function/Range Switch in the 1500VDC position.
4. Touch the red test lead and black test lead together. Observe the Digital Display; it should read 000 ±1 count.
5. Turn the Function/Range Switch counterclockwise to each DCV position while observing the Digital Display. With the test lead tips in contact, the Digital Display should read zero plus or minus one count and the decimal point positioned as follows:

200V	00.0
20V	0.00
2V	.000
200mV	00.0

6. Turn the Function/Range Switch to the 20MΩ position. With the two test lead tips separated, the Digital Display should read OL (overload).
7. Touch the test lead tips together and observe the Digital Display; it should read 0.00 or 0.01.
8. Turn the Function/Range Switch to each Ω position while observing the Digital Display. With the test lead tips in contact, the Digital Display should read 0 in each position. In the 200Ω position, the Digital Display may read 00.1 or 00.2 because of test lead resistance. The decimal point should be positioned as follows:

20MΩ	0.00	20kΩ	0.00
2MΩ	.000	2kΩ	.000
200kΩ	00.0	200Ω	00.0

9. Turn the Function/Range Switch to the 1000VAC position.

> **"W" The next step requires the measurement of the standard 120VAC household voltage. Be careful not to touch the test lead tips with fingers and do not allow the tips to contact each other.**

10. Measure the household voltage at a convenient AC wall socket. The Digital Display should show the appropriate voltage with a resolution of one volt.
11. Remove both probes from the AC wall socket.

Voltage Measurements

DC Voltage

1. Connect red test lead to V-Ω Input Connector and black test lead to COM Input Connector.
2. Set Function/Range Switch to desired DCV position. If magnitude of voltage is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.

> **"W" To avoid electrical shock hazard and/or damage to the instrument, do not attempt to measure voltages that might exceed 1500VDC or peak AC.**

4. Connect test leads to device or circuit being measured.
5. Turn on power to device or circuit being measured. Voltage value will appear on Digital Display along with the voltage polarity.
6. Turn off power to device or circuit being tested and discharge all capacitors before disconnecting test leads from device or circuit being tested.

AC Voltage

1. Connect red test lead to V-Ω Input Connector and black test lead to COM Input Connector.
2. Set Function/Range Switch to desired VAC position. If magnitude of voltage is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.

> **"W" To avoid electrical shock hazard and/or damage to the instrument, do not attempt to measure voltages that might exceed 1000VRMS or 1500V peaks.**

4. Connect test leads to device or circuit being measured.
5. Turn on power to device or circuit being measured. Voltage will appear on Digital Display.
6. Turn off power to device or circuit being tested and discharge all capacitors before disconnecting test leads from device or circuit tested.

AC Conversion Process

Understanding the AC conversion process in the multimeter will help the user to more fully utilize its measurement capability. The AC converter used in the HD100, HD110, and HD110T models is "average-responding." An RMS value is determined by first rectifying and filtering the signal to obtain the average value. The average value is then scaled upward by a factor of 1.11 to obtain the RMS value. The scaling factor of 1.11 is accurate when measuring sinusoidal waveforms as follows:

$$VRMS = \frac{Vavg\ \pi}{2\sqrt{2}} = 1.11\ Vavg$$

In measuring nonsinusoidal waveforms, however, significant errors can be introduced because of different scaling factors relating average to RMS values. Rough correction factors can be sometimes calculated for standard waveforms that are free from significant noise and distortion but accurate measurements of complex waveforms can be difficult to achieve.

RMS values of nonsinusoidal signals can be measured directly and more accurately with the HD130B which features a "True-RMS responding" converter. True-RMS response can be particularly useful in measuring complex or noisy signals for which even rough correction factors cannot be easily computed.

Converters of all types are limited by their frequency response and input dynamic range. Bandwidth defines the frequency range in which the conversion accuracy is within 3dB. The bandwidth of the HD130B is 100kHz. Measurements of complex signals will not be affected by converter bandwidth limitations unless there are significant harmonic components beyond 100kHz.

Crest factor is a measure of the input dynamic range of a True-RMS responding converter. It expresses the capability of the converter to handle a signal that has large peak values compared to its RMS value without saturating the converter circuitry and degrading the specified accuracy.

For the HD130B crest factor is defined and the ratio of the peak voltage to the RMS (AC coupled) voltage.

$$\text{Crest Factor} = \frac{\text{V peak}}{\text{VRMS}}$$

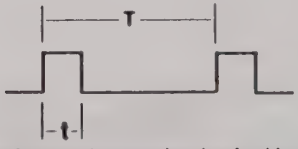
Crest Factor for an AC coupled pulse train is follows:

$$\text{Crest Factor} = \frac{1-x}{y}$$

where

$$x = \frac{t}{T}$$

$$y = \sqrt{x-x^2}$$



The HD130B is capable of accurately measuring signals with a crest factor from 1.0 to 5.0 on each voltage scale depending on the signal's value RMS. At full-scale (1999 counts), signals with crest

factor between 1.0 and 1.5 can be measured. Signals with a crest factor of 1.0 include a square wave or pure DC (peak voltage equals RMS voltage). An undistorted sine wave signal (crest factor = 1.414) can also be measured at full-scale.

At half scale (1000 counts), signals with crest factor between 1.0 and 3.0 can be measured without performance degradation. At or below 600 counts, signals with crest factors up to 5.0 can be measured. If the crest factor is not known, it can be determined by measuring the peak voltage with an oscilloscope and dividing by the RMS voltage measured by the multimeter. The crest factors and corresponding display readings for some typical waveforms are shown in Figure 3.

Total RMS Measurements

The HD130B permits measurement of the True-RMS value of the AC component of a signal. Sometimes, it is useful to be able to find the value of the AC and the DC components of the signal (such as measuring the power outputs of switching power supplies). To accomplish this:

1. Set the HD130B to the right VDC range, measure the DC component and record the result;

2. Set the HD130B to the right VAC range, measure the AC RMS component, record the result;

3. Figure the True-RMS value by the following formula:

$$\text{True-RMS} = \sqrt{(\text{AC RMS Component})^2 + (\text{DC Component})^2}$$

Current Measurements

DC Current

1. Connect red test lead to the A Input Connector for current measurements up to two amperes. For current measurements to ten amperes, using models with ten ampere capability, connect red test lead to the 10A Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired DCA position. If the magnitude of current is not known, set switch to highest range and reduce setting until satisfactory reading is obtained. When the 10A Input Connector is used, the Function/Range Switch should be placed in the 20 m/10A position.
3. Turn off power to device or circuit being tested and discharge all capacitors.
4. Open circuit in which current is to be measured. Securely connect test leads in series with the load in which current is to be measured.
5. Turn on power to circuit being tested.
6. Read current value on Digital Display.
7. Turn off all power to circuit being tested and discharge all capacitors.
8. Disconnect test leads from circuit and reconnect circuit that was being tested.

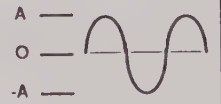
Meter Display Reading			
Input Waveform	HD130B AC True-RMS	HD100, HD110, HD110T Avg Responding	True-RMS (AC+DC) Total RMS = $\sqrt{AC^2+DC^2}$
Sine 	0.707A CF = 1.414	0.707A	0.707A CF = 1.414
Square	1.000A CF = 1.000	1.111A	1.000A CF = 1.000
Triangle	0.577A CF = 1.733	0.555A	0.577A CF = 1.733
Full Wave Rectified Sine	0.308A CF = 2.067	0.298A	0.707A CF = 1.414
Square	0.386A CF = 1.768	0.389A	0.500A CF = 2.000
50% Duty Cycle Pulse Train $T_0 = T_1$	0.500A CF = 1.000	0.555A	0.707A CF = 1.414
Variable Duty Cycle Pulse Train $X = T_0/T_1$ $Y = \sqrt{X - X^2}$	AY $CF = \frac{1-x}{Y}$	1.111 AY	$A\sqrt{X}$ $CF = \frac{1}{\sqrt{X}}$

Figure 3. Typical Input Waveforms and Meter Readings and Crest Factors (CF)

AC Current

1. Connect red test lead to A Input Connector for measurements up to two amperes. For current measurements to ten amperes, using models with ten ampere capability, connect red test lead to 10A Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired ACA position. If the magnitude of current is not known, set switch to highest range and reduce setting until satisfactory reading is obtained. When the 10A Input Connector is used, the Function/Range Switch should be placed in the 20m/10A position.
3. Turn off power to device or circuit being tested and discharge all capacitors.
4. Open circuit in which current is to be measured. Securely connect test leads in series with the load in which the current is to be measured.
5. Turn on power to circuit being tested.
6. Read current value on Digital Display.
7. Turn off all power to circuit being tested and discharge all capacitors.
8. Disconnect test leads from circuit and reconnect circuit that was being tested.

Resistance Measurements

All resistance ranges on the Multimeter are low-power ohms which allow accurate measurements of in-circuit resistance. (Use Diode Test Function for checking diode and other semiconductor junctions.)

1. Connect red test lead to V•Ω Input Connector and black test lead to COM Input Connector.
2. Set Function/Range Switch to desired Ω position. If magnitude of resistance is not known, set switch to highest range and reduce until satisfactory reading is obtained.
3. If the resistance being measured is connected to a circuit, turn off power to circuit being tested and discharge all capacitors.
4. Connect test leads to circuit being measured. When measuring high resistance be careful not to contact adjacent points, even if insulated, because some insulators have a relatively low insulation resistance, which may affect the resulting measurement.
5. Read resistance value on Digital Display. If a high resistance value is shunted by a large value of capacitance, allow Digital Display to stabilize.

Diode and Transistor Test Measurements

The special diode test function allows accurate measurements of forward voltage drops across diodes and transistor junctions. A constant-current source forces 2mA of current into the semiconductor junction under test, which results in the voltage drop being displayed on the Digital Display. This function also permits measurement of in-circuit semiconductor junctions with as

little as 500Ω in parallel with the transistor or diode. The limited current produced by the instrument in the Diode Test Function minimizes the possibility of damage to low-power semiconductor junctions, a common problem when using many analog meters.

Diode Tests

To perform diode test measurements, use the following procedure:

1. Connect the red test lead to the V•Ω Input Connector and the black test lead to the COM Input Connector.
2. Set Function/Range Switch to the Diode Test (—|◄—) position.
3. If the semiconductor junction being measured is connected to a circuit, turn off power to the circuit being tested and discharge all capacitors.
4. Connect test leads to device.
5. Read forward voltage drop on Digital Display.
   If the Digital Display reads OL, reverse the lead connections. The placement of the leads when the forward voltage is displayed (normally 600mV to 900mV) indicates the orientation of the diode. The red lead is then connected to the anode and the black lead is connected to the cathode as shown in Figure 4.

If OL is displayed with both lead connections, the junction is open.

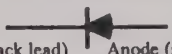


Figure 4. Placement of Leads in Respect to Anode and Cathode

If a low reading (less than 1V) is obtained with both lead connections, the junction is shorted internally or (if the junction is measured in a circuit) is shunted by a resistance less than 500 ohms. In the latter case the junction must be disconnected from the circuit in order to verify its operation.

Transistor Junction Tests

Transistors can be tested in the same manner as diodes by checking the two diode junctions formed between the base and emitter and the base and collector of the transistor. Figure 5 shows the orientation of these effective diode junctions for PNP and NPN transistors. Measurements between the collector and emitter should also be made to determine if a short is present.

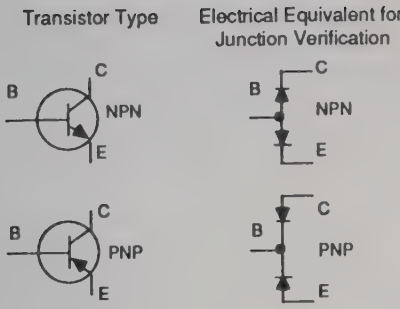


Figure 5. Orientation of Effective Diode Junctions for PNP and NPN Transistors

Transistor Beta Test

With a simple test fixture the Diode Test Function can be used to determine the DC current gain (beta) of a transistor. Beta is measured using a DC collector-to-emitter voltage (Vce) of about 1V and a collector current (Ic) of about 2mA.

The transistor beta test setup is shown in Figure 6 for an NPN transistor. For PNP transistors, the connections to the Multimeter should be reversed.

$$\text{Beta} = \frac{2000}{\text{Display Change in Digits}}$$

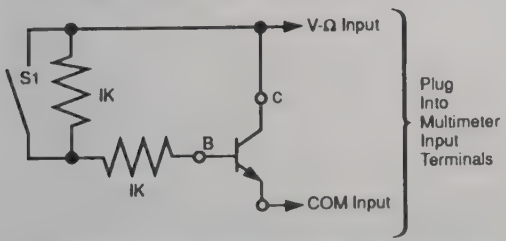


Figure 6. Test Fixture for Beta Measurements

To determine transistor beta, use the following procedure:

1. With all the connections made as shown in Figure 6 and with switch S1 open, record the displayed reading (ignore decimal point).

NOTE

If an overload indication is obtained, reverse the connections to the Multimeter.

If an overload indication is obtained regardless of meter orientation, or if a reading less than 0.200 is obtained, the transistor is probably defective.

2. Close switch S1 and record the new displayed reading (ignore decimal point).
3. Divide 2000 by the difference in digits between the reading obtained in Steps 1 and 2. The resulting number is the transistor DC beta.

Continuity and Capacitor Checks

Before the development of Digital Multimeters by Wavetek Corporation, quick continuity checks using a digital multimeter were not possible. Now, with the Insta-Ohms Quick Continuity Indicator, they can be done just as quickly and as easily as with an analog meter. This feature is particularly useful in circuit and cable tracing, but also may be used for troubleshooting small-value capacitors.

Continuity Checks

1. Place Function/Range Switch in any Ω range.
2. Connect red test lead to the V•Ω connector and the black test lead to the COM connector. With the test leads separated or measuring and out-of-range resistance, the Digital Display will indicate OL, Figure 7.
3. Place one test lead probe at one end of cable or circuit to be tested. Use the other test lead to trace the circuit or cable until the circuit is complete. When continuity is established, an Ω symbol will appear in the upper left-hand corner of the Digital Display, Figure 8. If contact in the cable or circuit is maintained long enough (about 1/4 of a second) the OL will disappear and the resistance value of the cable or circuit will appear next to the Ω symbol, Figure 9.

NOTE

The Insta-Ohms Quick Continuity Indicator quickly identifies completed circuit paths. The trigger point is approximately two to five times the maximum resistance measurable on the selected range.

Capacitor Checks

The Insta-Ohms Quick Continuity Indicator can be used to rough check capacitors with a value greater than or equal to 0.01μF. This feature can be a great aid in troubleshooting circuits in which an open or shorted bypass capacitor is suspected. Use the following procedure to check capacitors:

1. Place Function/Range Switch in 20MΩ range position.
2. Connect red test lead to V-Ω connector and the black test lead to the COM connector. With the test leads separated, the Digital Display will indicate OL, Figure 7.
3. Discharge the capacitor to be checked by briefly shorting the ends together.
4. Place red test lead probe at one end of capacitor. Place the black test lead at other end of capacitor.

Figure 7. Overload Symbol

Figure 8. Insta-Ohms Quick Continuity Indicator Symbol (Ω)

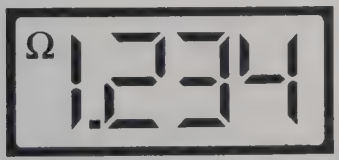


Figure 9. Insta-Ohms Quick Continuity Indicator Symbol (Ω) & Resistance Value

NOTE

Do not touch capacitor leads or test probe ends during capacitor check because proper operation of Insta-Ohms feature could be affected.

5. If the Insta-Ohms symbol (Ω) appears briefly and disappears, the capacitor is accepting a charge.

Mylar Capacitors

If the Insta-Ohms symbol does not appear, the capacitor is probably open. If a low resistance value appears, the capacitor is probably shorted.

Electrolytic and Tantalum Capacitors

A good capacitor will show a reading that rises steadily from 0.00Ω to infinity (OL). This reading could stabilize at a very high value (MΩ), depending on the size and quality of the capacitor. If the reading stabilizes at a low value, the capacitor is probably bad.

NOTE

Insta-Ohms can only be used to check capacitors with a value of 0.01μF or greater.

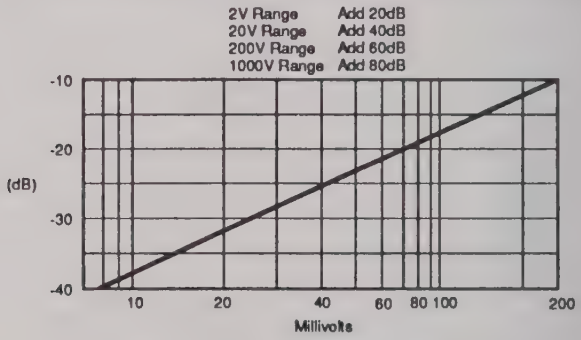


Figure 10. Decibel Conversion Chart

Decibel Measurements

In addition to its normal functions, the Multimeter can be used to measure decibels. The value obtained from this measurement can be used to indicate the gain and accuracy of electronic devices. The decibel (dB) is the logarithm of the ratio of two electrical signals; usually a certain amount of power across a fixed resistance is used as a reference and denoted as 0 (zero) decibels. In Figure 10, 0dB is defined as 1 milliwatt being dissipated in a 600Ω lead. Use the procedure in Section IV, page 11, AC Voltage, to determine AC voltage and the graph of Figure 10 to determine decibel value.

Temperature Measurement (HD 110T Only)

The temperature function of the multimeter is designed for use with an industry-standard type K thermocouple having a miniature or subminiature input connector. Use the following procedure to measure temperature.

1. Disconnect the test leads from the multimeter.
2. Insert type K thermocouple into the input connector at the top of the multimeter, above the LCD.
3. Place the Function/Range Switch in the T/200µ position.
4. Place the thermocouple probe in the area to be measured and read the meter in degrees.

NOTE

Thermocouple plug must be removed from the meter for normal voltage, current, and resistance readings.

Switching Between Celsius and Fahrenheit Temperature Modes

The HD110T is shipped from the factory set for the Fahrenheit mode. The simple procedure described below permits switching between Fahrenheit and Celsius modes. Either mode may be selected without recalibration.

1. Remove the back cover by removing the four screws and then lifting the cover.
2. Locate jumper connector JX on the input circuit board. Figure 11.
3. Place the jumper on the appropriate pins: 1 and 2 for Celsius; or 5 and 6 for Fahrenheit.
4. Reassemble the multimeter.

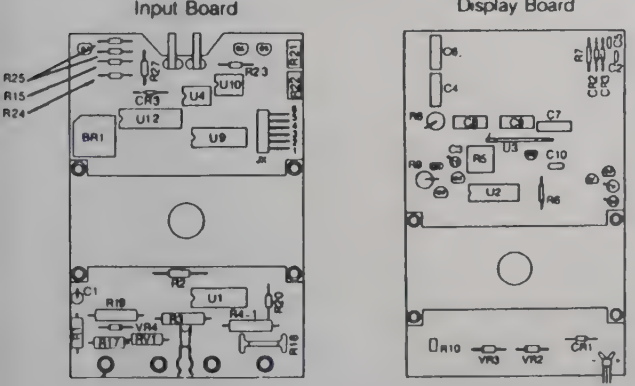


Figure 11. Components Locator for HD110T

Section V Specifications

General Specifications

The following specifications apply to the Heavy Duty Series Digital Multimeters.

Operating Temperature Range
0°C to +50°C

Storage Temperature Range
-40°C to +65°C with battery removed

Display
Shock protected 3½ -digit liquid-crystal display (LCD) with a maximum reading of 1999.

Power
Single, standard 9-volt transistor battery, NEDA 1604

Battery Life
Alkaline: 2,000 continuous hours, nominal.
Zinc-Carbon: 1,600 continuous hours, nominal.
Under typical usage, two years.

Low Battery Indicator
Decimal point blinks when 200 hours battery life remain.

Shock and Vibration
Meets MIL-T28800 Class II Type A Specifications.

Relative Humidity
0% to 80%, 0°C to 35°C; 0% to 70%, 35°C to 50°C.

Temperature Coefficient
0°C to 20°C, 30° to 50°C

Maximum Common Mode Voltage
1500VDC or peak AC.

Dimensions
7.0 inches (17.8 cm) long x 3.9 inches (9.9 cm) wide x 2.0 inches (5.1 cm) high.

Weight
19 ounces (543 gm) including battery.

Calibration
Accuracy specifications guaranteed for one (1) year, 20° C to 30° C.

Measurement Rate
Four measurements per second nominal.

Case
Specially reinforced high-impact, fire-retardant plastic, recessed switch and display.

Included with Instrument:
1. Nine-volt battery
2. Spare 2 amp fuse
3. TL-245 Probe Set
4. Operator's manual

DC Volts

General
Automatic polarity indication (+ and - indicated)

		ACCURACY (1 YEAR, 20°C to 30° C)	
RANGE	RESOLUTION	HD100, HD110 HD110T	HD 130B
±200mV	100µV	+ (0.25% reading	±(0.1% reading
±2V	1mV	+ 1 digit)	+ 1 digit)
±20V	10mV		
±200V	0.1V		
±1500V	1V		

Input Impedance (all ranges)
22MΩ

Normal Mode Rejection
Greater than 60dB above 49Hz.

Common Mode Rejection
Greater than 60dB above 49Hz.

Response Time
Less than one second.

Overvoltage Protection
1500VDC or peak AC, any range

AC Volts

Thsee specifications apply to the HD100, HD110, and HD110T. Accuracies apply to sine wave inputs only and for RMS with crest factors less than or equal to 1.5.

		ACCURACY (1 year, 20°C to 30°C)		
RANGE	RESO-LUTION	45Hz to 2kHz	2kHz to 5kHz	HD130B only 5kHz to 10kHz
200mV	100µV			
2V	1mV	±(0.75% reading + 3 digits)	±(1.5% reading +5 digits)	±(2.5% reading +9 digits)
20V	10mV			
200V	0.1V			
1000V	1V			

Conversion Technique
Average sensing, calibrated to display RMS value of sine wave.

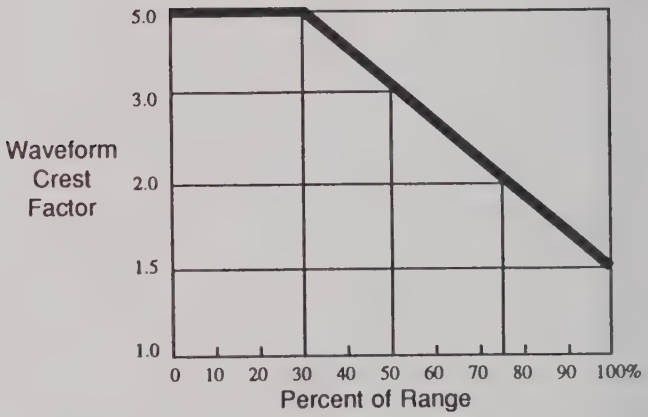
Input Impedance (all ranges)
2.2MΩ, shunted by less than 75pF

Response Time
Less than two seconds

Maximum Input Voltage
1000VRMS AC(1500V peak) or 250VDC (5 sec maximum above 450VRMS on 20mV range)

The following specifications apply to the HD130B.

		ACCURACY (1 YEAR, 20°C TO 30°C)				
RANGE	RESO-LUTION	45Hz to 2kHZ	2kHz to 5kHz	5kHz to 10kHz	10kHz to 20kHz	20kHz to 40kHz
200mV	100µV	±(0.6% reading +3 digits)	±(1.0% reading +4 digits)	±(1.5% reading +5 digits)	±(2.5% reading +7 digits)	±(5% reading +16 digits)
2V	1mV					
20V	10mV					
200V	0.1V	±(0.6% reading +3 digits)	±(1.0% reading +4 digits)	±(1.5% reading +5 digits)	±(2.5% reading +7 digits)	Not Specified
1000V	1V					



Crest Factor (HD 130B)
Allowable crest factor (peak/RMS ratio) varies from 1.0 to 5.0.

Conversion Technique (HD 130B)
True RMS responding (AC coupled)

Input Impedance (all ranges)
2.2 megohms, shunted by less than 75pF

Response Time
Less than two seconds (on HD130B, above 10% of full-scale)

Overvoltage Protection
HD100, HD110, HD110T: 1000VRMS AC (1500V peak) or 250VDC (five seconds maximum above 450VRMS on 200mV range)
HD130B: 1000VRMS AC (1500V peak) or 1500VDC (200mV range, 500VRMS or DC max.)

DC Current

		Accuracy (1 Year, 20°C to 30°C)	
Range	Resolution	HD100, HD110 HD110T	HD130B
±200µA	100nA	±(0.75% reading	±(0.35% reading
±2mA	1µA	+ 1 digit)	+ 1 digit)
±20mA	10µA		
±200mA	100µA		
±2A	1mA		
±10A*	10mA	±(1.5% reading	±(1.0% reading
		+ 1 digit)	+ 1 digit)

*Not applicable to HD100.

General
Automatic polarity indication (+ and - indicated)

Response Time
Less than one second

Voltage Burden
200µA to 200mA ranges: 250mV maximum at full-scale
2A range: 700mV maximum at full-scale
10A range: 600mV maximum at full-scale

Overcurrent Protection - A Input
Two amperes, 600V (fused)

Overcurrent Protection - 10A Input
15 amperes, 600V (fused)
100,000 ampere interrupt
(input is rated up to 20 amperes for 30 seconds)
(Not applicable to HD100)

AC Current

		Accuracy (1 Year, 20°C to 30°C)				
		45Hz to 400Hz		400Hz to 2kHz		2kHz to 5kHz
Range	Resolution	HD100 HD110 HD110T	HD130B	HD100 HD110 HD110T	HD130B	HD130B
20µA 2mA 20mA 200mA	100nA 1µA 10µA 100µA	±(1.5% reading +3 digits)	±(0.9% reading +3 digits)	±(1.5% reading +3 digits)	±(0.9% reading +3 digits)	±(1.5% reading +3 digits)
2A	1mA	±(1.5% reading +3 digits)	±(0.9% reading +3 digits)	±(1.5% reading +3 digits)	±(0.9% reading +3 digits)	
10A*	10mA	±(2.0% reading +3 digits)	±(1.5% reading +3 digits)			

*Not applicable to HD100

Crest Factor (HD130B)
1.0 to 5.0 (Refer to graph on page 26.)

Conversion Technique
Averaging Models: Average sensing, calibrated to display RMS value of sine wave.
HD 130B: True-RMS responding (AC coupled)

Response Time
Less than two seconds (on HD130B, above 10% of full-scale)

Voltage Burden
200µA to 200 mA ranges: 250mV maximum at full-scale
2A range: 700mV maximum at full-scale
10A range: 600mV maximum at full-scale

Overcurrent Protection - A Input
Two amperes, 600V (fused)
100,000 ampere interrupt
(input is rated up to 20 amperes for 30 seconds)
(Not applicable to HD100)

Resistance

The following specifications apply to the Heavy Duty Series, unless otherwise indicated.

			ACCURACY (20°C to 30°C)	
RANGE	RESOLUTION	MAX. TEST CURRENT	HD100, HD110, HD110T	HD130B
200Ω 2kΩ 20kΩ 200kΩ 2MΩ	0.1Ω 1Ω 10Ω 100Ω 1000Ω	2.5mA 250µA 25µA 2.5µA 250nA	±(0.5% reading + 1 digit)	±(0.2% reading + 1 digit)
20MΩ	10kΩ	25nA	±(1.5% reading + 1 digit)	±(1.0% reading +1 digit)

General

Low-power ohms on all ranges

Maximum Open Circuit Voltage

0.5V all ranges

Maximum In Range Voltage (low power ohms)

250mV, all ranges

Response Time

Less than one second, except 20MΩ range, less than four seconds

Overload Protection

600VDC or RMS AC, any range

Diode Test

Range
0V to 2V

Resolution
1mV

Accuracy
HD100, HD110, HD110T: ±(0.25% reading plus two digits)
HD130B: ±(0.1% reading plus two digits)

Accuracy Conditions
One year, 20°C to 30°C

Test Current
2mA, ±20%

Response Time
Less than one second

Overload Protection
600VDC or RMS AC

Temperature (HD110T Only)

Factory Set Mode
Fahrenheit

Ranges
-20°C to 1260°C
-4°F to 1999°F

Resolution
1°C or °F

Accuracy

(at 25°C ±5°C ambient)

RANGE	ACCURACY
-20°C to -1°C	±4°C
0°C to 300°C	±3°C
301°C to 400°C	±1% of Reading ±2°C
401°C to 600°C	±2% of Reading ±3°C
601°C to 1260°C	±3% of Reading
-4°F to 31°F	±6°F
32°F to 572°F	±5°F
573°F to 800°F	± 1% of Reading ±2°F
801°F to 1000°F	± 2% of Reading
1001°F to 1999°F	± 3% of Reading

Thermocouple Type

Type K

Input Connector

Miniature or subminiature

Insta-Ohms® Quick Continuity Indicator

Response Time

Less than 100 milliseconds

(Model HD110): Insta-Ohms Continuity Indicator initiates a single audible tone burst of approximately 3500Hz concurrent with the Insta-Ohms display.

Section VI Maintenance

This section describes maintenance procedures, calibration, and troubleshooting. In addition, a general statement on service policy is included. Any questions regarding warranty repair or instrument servicing should be directed to Wavetek Corporation or to a Service Center (see Section VIII, page 45 for addresses).

Troubleshooting

Except for the replacement of the battery or fuse, repair of the multimeter should be performed only by a Factory Authorized Service Center or by other qualified instrument service personnel.

CAUTION

The CMOS multiprocessor chip U4 is subject to damage created by electrostatic discharge. This component should be handled only by qualified personnel equipped with antistatic grounding devices.

If the multimeter is not performing properly, take the following steps before returning it for repair.

1. Check the battery and fuse connections.
2. Check to ensure that the Function/Range Switch is in the correct position for the parameter and value range being measured, and that the measurement value is within the capability of the instrument.
3. Review and comply with the operating instructions contained in Section IV of this manual.
4. Check test leads for breaks or cracks. Ensure that test leads are inserted fully into the connectors.
5. Check to see that the ambient environment in which the instrument is being used is within specifications given in Section V of this instruction manual.
6. If the decimal point in the Digital Display is blinking, the battery is probably low. Replace the battery, using procedure on page 35.
7. If the Digital Display is blank with the unit turned on, the battery is probably dead. Replace the battery, using procedure on page 35.
8. If operation is normal in all functions and ranges except AC and DC current, the fuse is probably blown. Replace fuse, using procedure on page 35.

If the preceding steps do not remedy the problem, refer to the following pages for WARRANTY REPLACEMENT and NON-WARRANTY REPAIRS.

Factory Service

The warranty statement for the Heavy Duty Series Multimeters appears at the front of this manual. Read it carefully before requesting warranty repairs.

Any Heavy Duty Series multimeter claimed to be defective should be returned to Wavetek Corp. Follow the instructions below and in Section VIII.

Non-warranty Repairs

Any out-of-warranty meter that is defective, but repairable, can be repaired by an Authorized Service Center or by Wavetek Corp. (See Section VIII, page 45.) The repaired unit carries a six (6) month warranty. Contact any Authorized Service Center for their current non-warranty repair rates. The standard charge for repair at the Factory Service Center is $60.00.* Be sure to include (a) the specified payment or (b) a purchase order specifically authorizing repair and indicating the correct fee or the Multimeter will be returned to sender C.O.D.

Shipping Instructions

Instruments returned for calibration or repair should be shipped with the following information or items: company name, your name, address, telephone number, proof of purchase (for warranty repairs), a description of the problem encountered or service required, and the appropriate service charge. Please include any test leads you have been using with the meter.

Service charges should be remitted in the form of a check, money order or purchase order made payable to Wavetek Corp.

The multimeter should be shipped with transportation charges prepaid to the appropriate address in Section VIII (see page 45).

The multimeter will be returned with transportation charges paid by Wavetek Corp.

Maintenance Procedures

Regular operator maintenance of the Multimeters consists of: cleaning case and window, batter replacement, and fuse replacement. All other repairs should be performed by a Factory Authorize Service Center or other qualified instrument service personnel.

*Prices subject to change without notice.

Cleaning Case and Window

> **"P" Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These chemicals will react with plastics used in construction of case.**

The case is made of an advanced generation plastic which resists damage from many chemical solvents including gasoline. The front panel and case should be cleaned with a mild solution of detergent and water. Apply sparingly with a soft cloth and allow to dry completely before using.

Battery Replacement

> **"W" To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing back cover.**

1. After disconnecting test leads and turning off Multimeter, remove back cover by removing the four rear screws, and then lift off back cover.

> **"P" Failure to turn off the instrument before installing the battery could result in damage to the battery if it is connected to the battery terminal incorrectly.**

2. The battery is located in the front part of the case as shown in Figure 12, page 36. Disconnect battery from instrument and replace with a standard 9V transistor battery.
3. Replace back cover and secure with four screws, taking care to seat O-ring seal uniformly.

Fuse Replacement

> **"W" To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing back cover.**

1. Disconnect leads, turn off meter, remove four back cover screws, remove cover.
2. The 2A fuse is located next to the battery, between the A and COM input jacks. Remove the fuse by pulling the ribbon.
3. Replace center of ribbon across the fuse opening and press new fuse into place. Be sure ribbon is between fuse clips, not caught on the clips.

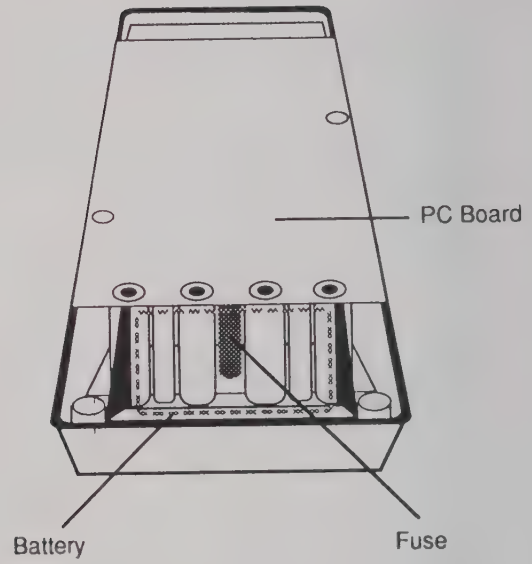


Figure 12. Multimeter, Back Cover Removed

"W" **To prevent fire, use Type 2A/600V Wavetek P/N FP260 and Type KTK or KLK15A/600V fuses only. The 10A fuse clips must be insulated from battery. Check condition of battery-fuse insulator and replace if damaged.**

4. Replace back cover and secure with four screws.

"W" **Do not operate Multimeter with back cover removed (except during calibration).**

Calibration

To maintain the specifications described in Section V of this instruction manual, we recommend that the multimeter be calibrated once each year and/or after it is repaired. For information regarding calibration procedures, please refer to the Heavy Duty Series Service Manual.

Service Manual

A complete service manual (FG-3000-940-143) is available from Wavetek Corp., for those users who desire to service their own multimeters. To obtain a copy of this manual, send $15.00* (postage and handling) in the form of a check, money order, or a purchase order made payable to Wavetek Corp. See shipping address in Section VIII.

Multimeter Storage

"W" If Multimeter is to be stored at temperatures above 122°F (50°C), remove battery.

*Prices subject to change without notice.

Accessory Descriptions

This section provides a description of the Heavy Duty Series Multimeter accessories that are available from Wavetek Corporation.

Vinyl Carrying Case (VC201)

The vinyl carrying case is constructed of durable, padded vinyl and will accommodate any Heavy Duty Series Multimeter. The case has room for the multimeter, operator's manual, and the TL245 Probe Set without adding any unnecessary bulk. The back of the case has a handy belt loop.

Deluxe Carrying Case (DC205)

Handsome, yet rugged, this case offers maximum protection for any Heavy Duty Series Multimeter and is designed to permit in-case operation. Constructed of rigid, leather-grained vinyl, the deluxe case has inside compartments for storing the multimeter, test lead set, and the operator's manual.

Deluxe Carrying Case (DC207)

Tough and attractive, this case offers maximum protection for any Heavy Duty Series Multimeter and is designed to permit in-case operation. Constructed of rigid, leather-grained vinyl, the deluxe case has inside compartments for storing the instrument, test lead set, the operator's manual, and an extra compartment for a current clamp or small tools.

High Voltage Probe (HV231-22)

The HV231-22 High Voltage Probe extends the DC voltage measurement capability of any Heavy Duty Series Multimeter to 50kV. This accessory is essential for television and CRT terminal service where second anode voltages must be measured. This probe contains a precision 1000:1 resistor divider that scales high voltages down to a level that the multimeter can handle safely. The high input impedance of the probe minimizes circuit loading and assures accurate measurements.

HIGH VOLTAGE PROBE SPECIFICATIONS

Voltage Range:	40kVDC
Input Resistance:	1000MΩ
Input Impedance Compatibility:	22MΩ or less
Division Ratio:	1000 to 1
Accuracy:	DC ±2%, AC ±3%
Temperature Coefficient:	less than 200ppm/°C

OPERATION WITH HV231-22 HIGH VOLTAGE PROBE

"W" The HV231-22 High Voltage Probe is used to measure potentially lethal voltages. Always disconnect power and discharge voltage source before connecting or disconnecting the High Voltage Probe.

When the High Voltage Probe is used, the probe replaces the standard test leads. The probe is connected to the multimeter in the same manner as the TL245 Probe Set leads, and measurements are made as described in Section IV except that, because the probe is a precision 1000:1 divider, the Digital Display readings are in kilovolts. A measured value of 50kV will therefore read +50.0 with the Function/Range Switch in the 200VDC position.

RF Probe (RF241)

The peak detecting RF241 RF Probe extends the VAC measuring capability of Heavy Duty Series Multimeters to 200MHz. It provides VDC calibrated to equal the RMS value of a sine wave.

RF241 RF PROBE SPECIFICATIONS

Frequency Range:	2kHz to 200MHz
Accuracy:	±(1% input + 50mV), from 2kHz to 10MHz
	±1dB from 10MHz to 100MHz
	±6dB from 100MHz to 200MHz
Maximum Reading:	25VRMS
Response:	Peak sensing, RMS calibrated
Input Impedance:	1.5MΩ in parallel with 7pF
Overvoltage Protection:	130VRMS at 60Hz or 250VDC

OPERATION WITH RF241 PROBE

The RF241 RF Probe is connected to the meter like the TL245 Probe Set leads. Measurements are made as described in Section IV. Use appropriate VDC range from 200mV to 200V and read voltage signal directly in VRMS.

AC Current Clamp (CT231)

The CT231 AC Current Clamp extends the AC current measurement capability of any Heavy Duty Series Multimeter to 150A without breaking the circuit under test. The 1000:1 current transformer allows direct reading in amperes when used with the 200mA AC current range of the multimeter.

CT231 CURRENT CLAMP SPECIFICATIONS

Range:	2A to 150A RMS AC
Frequency Range:	30Hz to 1kHz
Accuracy:	±3% (50Hz to 1kHz)
Division Ratio:	1000:1
Circuit-to-Ground Voltage:	660 VRMS maximum
Maximum Conductor Size:	0.45 inch (11.4 mm)

OPERATION WITH CT231 AC CURRENT CLAMP

The CT231 AC Current Clamp is connected to the A and COM Input Connectors of the multimeter in place of the TL245 Probe Set leads. The jaws of the current clamp are placed around one of the current carrying conductors. In the 200mA ACA position, current is read directly in amperes.

AC Current Clamp (CT232)

The CT232 AC Current Clamp extends the AC current measurement capability of any Heavy Duty Series Multimeter to 1000A by use of a 1000:1 current transformer. The clamp-on design permits AC current measurements without breaking the circuit under test.

CT232 AC CURRENT CLAMP SPECIFICATIONS

Range:	1A to 1000A RMS AC
Frequency Range:	40Hz to 10kHz
Accuracy:	±2%
Division Ratio:	1000:1
Circuit-to-Ground Voltage:	660VRMS maximum
Maximum Conductor Size:	2.125 inches (54mm)

OPERATION WITH CT232 AC CURRENT CLAMP

The CT232 AC Current Clamp is connected to the A and COM Input Connectors of the multimeter in place of the TL245 Probe Set leads. The jaws of the current clamp are placed around one of the current carrying conductors. With the multimeter in the 2A ACA position, the displayed value is multiplied by 1000 to obtain measured current in amperes.

AC/DC Current Clamp (CT233)

The CT233 Current Clamp will allow any Heavy Duty Series Multimeter to measure electrical current up to 600 amps (AC, DC or even AC on DC) without breaking the circuit being measured. Current levels sensed by this clamp are translated into a corresponding 1000:1 mV output that is read by the meter using the AC or DC mV input ranges. This design is also unique in that the accuracy of the readings is not affected by the position of the current carrying circuit within the clamp jaws. A Zero Adjustment knob is also included to minimize the effect of stray magnetic fields, amplifier drift and hysteresis.

CT233 AC/DC CURRENT CLAMP SPECIFICATIONS

Range (AC & DC):	0 to 600A
Frequency Range (AC):	30Hz to 400Hz
Accuracy (DC):	±(2% reading + 1A)
Division Ratio:	1000:1
Circuit-to-Ground Voltage:	2000VRMS maximum for one minute
Maximum Conductor Size:	45mm
Accuracy: (AC ≤ 65Hz):	0-100A ±(2% reading + 0.5A)
	100-600A ±(2% reading + 1A)
(AC > 65Hz):	0-100A ±(3% reading + 0.5A)
	100-300A ±(3% reading + 1A)
	300-400A ±(4% reading + 1A)
	400-600A ±(6% reading)

OPERATION WITH CT233 AC/DC CURRENT CLAMP

The CT233 AC/DC Current Clamp is connected to the V-Ω and COM Input Connectors of th multimeter in place of the TL245 Probe Set test leads. The jaws of the current clamp are place around one of the current carrying conductors. Current lower than 200A may be read directly b setting the meter for either the 200mVAC or the 200mVDC (depending upon the type of current on the meter. For higher currents, select either the 2VAC or 2VDC range and multiply all reading by 1000.

AC Current Clamp (CT234A)

The CT234A AC Current Clamp extends the AC current measurement capability of any Multime ter to 400A without breaking the circuit under test. The 1000:1 current transformer allows direc reading in amperes when used with the 200mA AC current range of the multimeter.

CT234A AC CURRENT CLAMP SPECIFICATONS

Range:	4 to 400A RMS AC
Frequency Range:	40Hz to 1kHz
Accuracy:	±3%
Division Ratio:	1000:1
Circuit-to-Ground Voltage:	660 VRMS maximum
Maximum Conductor Size:	1.375 inches (34.9mm) diameter or 2.5 inches (63.5mm) wide

OPERATION WITH CT234A AC CURRENT CLAMP

The CT234A AC Current Clamp is connected to the A and COM Input Connectors of th multimeter in place of the TL245 Probe Set leads. The jaws of the current clamp are placed aroun one of the current carrying conductors. With the multimeter in the 200mA ACA position, curre is read directly in amperes.

Heavy Duty, Insulated Alligator Clips (TL246B)

Two each (one red, one black). One piece silicone wire and heavy duty alligator clip. Meter en of each lead wire is terminated with a retractable sheath banana plug. Comes with durable cordu carrying case. Fits all 300 Series, HD Series, 200 Series, 800/850, 3000 Series and Tech Seri Multimeters, as well as the RMS225 and the HD153.

Surface Mount Tweezer Probe (TL247)

Tweezer clip with permanently attached lead wires specifically designed for testing small Surface Mount Devices (SMDs) such as resistors and capacitors. Meter end of each lead wire is terminated with a retractable sheath banana plug. Fits all 300 Series, HD Series, 200 Series, 800/850, 3000 Series and Tech Series multimeters, as well as the RMS225 and the HD153.

Test Lead Accessory Kit (DL243B)

Basic test lead kit. Includes solder-resistant, silicone lead wires, and several types of interchangeable probe tips (standard probe tips, insulated alligator clips and spade lugs.) Meter end of each lead wires is terminated with a retractable sheath banana plug. Comes with durable cordura carrying case. Fits all 300 Series, HD Series, 200 Series, 800/850, 3000 Series and Tech Series multimeters, as well as the RMS225 and the HD153.

Deluxe Test Lead Accessory Kit (DL248B)

Same as DL243B with the addition of two crimp-style spring hooks and a 2", needle-sharp probe tip extender that fits over the tip of standard probes. Comes with durable cordura carrying case. Fits all 300 Series, HD Series, 200 Series, 800/850, 3000 Series and Tech Series multimeters, as well as the RMS225 and the HD153.

SMD Deluxe Test Lead Kit (TL249)

Special test lead kit designed to ease testing of SMD circuits. Contains all of the components of the DL248A, plus a TL247 and two Small Outline Integrated Circuit (SOIC) test clips (16 and 28 pin versions). Comes with durable cordura carrying case. Fits all 300 Series, HD Series, 200 Series, 800/850, 3000 Series and Tech Series multimeters, as well as the RMS225 and the HD153.

Individual Test Lead Replacement Parts

Silicone lead wires for DL243B, DL248B and DL249 ..... (TL901)
Standard probe tips for DL243B, DL248B and DL249 ..... (TL902)
Spring hooks for DL243B, DL248B and DL249 ..... (TL903)
2" needle tip extender for DL243B, DL248B and DL249 ..... (TL904)
Standard alligator clips for DL243B, DL248B and DL249 ..... (TL905)
Spade lugs for DL243B, DL248B and DL249 ..... (TL906)

Temperature/Voltage Converter (TC253)

The TC253 converts type K thermocouple voltages for use with any Heavy Duty Series DMM
It interfaces between the DMM and any type K thermocouple or probe using a standard type
miniature or subminiature connector. The display is switch-selectable to read in degrees C or

TEMPERATURE/VOLTAGE CONVERTER SPECIFICATIONS

Accuracy: *22°C ±3°C Ambient

TEMPERATURE RANGE		ACCURACY
°C	°F	
-50° to -10°	-58° to +14°	1.2% rdg. + 2.5°C or 4.5°F
-10° to +200°	+14° to +392°	0.5% rdg. + 1.5°C or 2.7°F
+200° to +500°	+392° to +932°	0.7% rdg. + 1.5°C or 2.7°F
+500° to +900°	+932° to +1652°	1.4% rdg. + 1.5°C or 2.7°F

*For total measurement accuracy, include error due to meter and thermocouple.

OPERATION WITH TC253 TEMPERATURE/VOLTAGE CONVERTER

1. Plug TC253 into V-Ω and COM inputs of multimeter.
2. Plug in type K thermocouple connecter at input, switch to °C or °F . Type K thermocoup
   accessories, TP254 (Probe with four foot lead) and TP255 (four foot leads) are available for u
   with this accessory.
3. Select 200mVDC range (if "OL," select 2VDC range) and read display in degrees.

Fuse Pack (FP260)

Each pack contains four 2A/600V fuses for the Heavy Duty Series Digital Multimeters.

Section VIII Service Centers

Factory Service

Read the warranty before requesting warranty or non-warranty repairs.

Shipping Instructions

A multimeter returned for calibration or repair should be shipped with the following: your company name (if applicable), your name, address, telephone number, proof of purchase (for warranty repairs), a description of the problem encountered or service required, and any test leads used with the meter.

Ship the multimeter and test leads in a sturdy box to the following address:

For U.S.A.:	**For U.K.:**	**For Canada:**
Wavetek Corp.	Wavetek Ltd.	(See list of
9045 Balboa Avenue	Hurricane Way, Norwich	service centers,
San Diego, CA 92123	NR6 6JB, United Kingdom	page 47)
Tel: (619) 279-2200	Tel: 0603 404824	

ATTN: Instrument Repair / Service

The multimeter will be returned with the shipping charge paid by Wavetek Corp. For questions in North America, contact the Instrument Repair & Service Dept. at (619) 279-2200.

Service & Shipping Instructions for Other Nations

Contact your local Wavetek Corp. dealer or distributor where the multimeter was purchased or refer to the list on beginning page 48.

Service Centers - U.S.A

Alabama
Arnolds Instrumentation
3258 Spring Hill Road
Mobile, AL 36607
(205) 478-3230

California
Standard Meter Labs
236 Rickenbacher Circle
Livennore, CA 94550
(415) 449-0220

Wavetek Corp.
9045 Balboa Avenue
San Diego, CA 92123
(619) 279-2200

Colorado
Instrument Repair Labs
2100 W. 6th Avenue #A
Broomfield, CO 80020
(303) 469-5375

Georgia
Peach State Instruments
108 Kipling Drive
Marietta, GA 30067
(404) 971-5050

Illinois
Metermaster, Inc.
2055 Army Trail Rd., Suite 134
Addison, IL 60101
(708) 268-8100

Indiana
Electro Lab Services
1302 N. Fulton Avenue
Evansville, IN 47712
(812) 423-5211

Louisiana
Industrial Instrument Works
5745 Salmen Avenue
Harahan, LA 70123
(504) 733-8355

Maryland
EIL Instruments
10 Loveton Circle
Sparks, MD 21152
(301) 771-4800

Massachusettes
Cal-Tek
20 Republic Road
N. Billerica, MA 01862
(508) 667-8541

EIL Instruments
21 'A' Street
Burlington, MA 01803
(617) 272-9450

Minnesota
Instrumentation Services
957 Winnetka Avenue North
Minneapolis, MN 55427
(612) 544-8916

Missouri
Industrial Service Labs
4354 Olive Street
St. Louis, MO 63108
(314) 535-5760

New York
EIC Electronics
85 Avenue East
Rochester, NY 14621
(716) 544-4392

EIL Instruments
9020 Wehrle Drive
Clarence, NY 14031
(716) 634-8500

Instrument Mart
295 Community Drive
Great Neck, NY 11021
(516) 487-7430

Oklahoma
Central Instrument Labs
3158 S. 108th E. Avenue
Tulsa, OK 74146
(918) 622-0114

Ohio
Unitek
865 Cleveland Avenue
Columbus, OH 43201
(614) 291-9909

Oregon
Westcon, Inc.
5101 N. Interstate Avenue
Portland, OR 97217
(503) 283-0132

Pennsylvania
EIL Instruments, Inc.
701 Rodi Road
Pittsburgh, PA 15235
(412) 823-2255

Sunshine Instruments, Inc.
1810 Grant Avenue
Philadelphia, PA 19115
(215) 673-5600

Texas
EIL Instruments
7385 Ashcroft Street
Houston, TX 77081
(713) 271-3100

Crompton Metermaster, Inc.
3405 Express Drive
Garland, TX 75041
(214) 271-5671

Meters & Instruments
6428 Gulf Freeway
Houston, TX 77023
(713) 644-1631

Washington
EIL Instruments
2883 152nd Avenue NE
Redmond, WA 98052
(206) 882-3222

Service Centers - Canada

Alberta
Kingsway Aviation
4238 91 'A' Street
Edmonton T6E 5V2
(403) 463-5264

British Columbia
Miller Instruments
55 East 5th Avenue
Vancouver V5T 1G7
(604) 876-7544

Manitoba
Probe Industrial Electronics
1874 Portage Avenue
Winnipeg R3J 0H2
(204) 885-9320

Ontario
BCS Electronics
980 Alness Street #7
Downsview M3J 2S2
(416) 602-8550

Quebec
Projean Ltd.
1332 Rue Belanger East
Montreal H2G 1A1
(514) 273-8331

Primo Instruments
11235 Boul. L'Archeveque
Montreal-Nord H1H 3A8
(514) 329-3242

Service Centers - Foreign

Angola
Technidata Ltd.
P.O. Box 1619
Rua Reverendo Agostinho Pedro
Neto 21-21A
LUANDA
Tel: 32025/32309 Tlx: 3019

Australia
Warburton Franki
32 Parramatta Road
LIDCOMBE, NSW2141
Tel: 61-02-648-5455
Fax: 61-02-647-1545

Austria
Lipschitz & Co. GmbH
Felbigergasse 38
1140 WIEN
Tel: 0222-940621 Tlx: 133378
Fax: 0222-944174

Bahrain
Al-Jishi Corporation
P.O. Box 617
Al-Khalifa Road
MANAMA
Tel: 253297 Tlx: 8371

Belgium
Mecotronic sa/nv
Nieuwelaan 58
1860 MEISE
Tel: 02-269 07 48 Tlx: 65602
Fax: 2699455

COMECON Countries (D.D.R., Czechoslovakia, Bulgaria, Romania, Poland)
C.A.T. Electro Ltd.
20 Haymarket Terrace
Edinburgh EH12 5JZ
Scotland, United Kingdom
Tel: 031-3467050 Tlx: 727563
Fax: 031-3467065

Denmark
T.O. Elektronik
Ballerup Byveg 222
BALLERUP 2750
Tel: 42-658200 Tlx: 35293
Fax: 42-680300

Egypt
Etico Scientific
3 Ahmed Heshmat Street
P.O. Box 1653
Zamalek, CAIRO
Tel: 403041/407733 Tlx: 93382

Finland
Dualtek OY
P.O. Box 14
ESPOO 02321
Tel: 90-801991 Tlx: 123369
Fax: 90-8019911

France
Beckman Industrial Sarl
1Bis Ave du Coteau
93220 GAGNY
Tel: (01) 43027606 Tlx: 212971
Fax: (01) 43817252

Germany
Beckman Industrial Components GmbH
Frankfurter Ring 115
8000 MÜNCHEN 40
Tel: (089) 38870 Tlx: 5216197
Fax: (089) 3887238

Greece
Micronics Ltd.
46 Kritis Street
16451 Argyrouspolis, ATHENS
Tel: 01-9914786 Tlx: 216574

Hungary
Dahms Elektronik
Wienerstrasse 287
8051 GRAZ, Austria
Tel: 316-64030 Tlx: 31099
Fax: 316-6403029

Iceland
Karl Asgeirsson Rafeindataeknir
P.O. Box 406
121 REYKJAVIK
Tel: 1-622884 Tlx: 946240
Ref: 19023785

Iran
Zeefax Ltd., Zeefax House
320 King Street
London W6 ORR, UK
Tel: 01-7487808 Tlx: 8813278
Fax: 01-7487188

Ireland
Neltronics Ltd.
John F. Kennedy Road
Naas Road
DUBLIN 12, EIRE
Tel: 503560 Tlx: 24837 Fax: 552789

Israel
Racom Electronics LTD.
P.O. Box 21120
TEL AVIV 61210
Tel: 03491922 Tlx: 33808
Fax: 03491576

Italy
Beckman Industrial Componenti Srl
Via Arese 11
20159 MILANO
Tel: (02) 6888951, Tlx: 330484
Fax: (02) 6896995

Jordan
Scientific & Medical
Supplies Co. P.O. Box 1387
AMMAN
Tel: 24902, Tlx: 21456

Kuwait
AZ Trading Co.
P.O. Box 25752
Jaber Al-Mubarak Street
SAFAT
Tel: 2442208, Tlx: 22707

Lebanon
Elco Ltd.
P.O. Box 136, ANTELIAS
Tel: 894420; 894699, Tlx: 22867

Malta
Fabian Enterprises
20, Msida Road, GZIRA
Tel: 513283, Tlx: 1837

Morocco
Sicotel AS
Complexe Commercial Des Harbous
Tour C 3éme Etage, Ave Des Forces
Armées Royales, CASABLANCA 01
Tel: 010-212312270, Tlx: 27604M
Fax: 010-212316545

Netherlands
Diode B.V.
Meidoornkade 22, AE Houten 3992
Tel: 3403-91234, Tlx: 47388
Fax: 3403-77904

Norway
Hellermann Haugerud A/S
Sandakerveien 110, 0483 OSLO 4
Tel: (02) 156012, Tlx: 18469
Fax: (02) 156129

Oman
Photocentre Comcent
P.O. Box 3115 (Ruwi)
MUSCAT
Tel: 773948 Tlx: 3499

Portugal
Decada, Equipamentos Electronicos Lda
Miraflores, Lote 102-B Alges
LISBOA 1495
Tel: 1410/34/20 Tlx: 15515
Fax: 14101844

Qatar
Qatar Trading Co.
P.O. Box 51, DOHA-QATAR
Tel: 323773 Tlx: 328642 Fax: 328642

Saudi Arabia
Mejdaf Establishment
P.O. Box 2002
RIYADH 11451
Tel: 4013206/4055240
Tlx: 202787

South Africa
Bowthorpe Hellermann Deutsch Ltd.
80 Mimetes Rd, Denver 2094
P.O. Box 27063, Benrose 2011
JOHANNESBURG
Tel: 11-6161960, Tlx: 4-28237
Fax: 11-6164715

Spain
Electronica Y Proyectos SA
Fernando Garrido 12
MADRID 28015
Tel: 341-4468141 Tlx: 42615
Fax: 341-4484750

Sweden
Q Instrument AB
P.O. Box 515, S-145
63 NORSBORG
Tel: 0753-86155 Fax: 0753-84414

Switzerland
W. Moor AG
Bahnstrasse 58, 8105 Regensdorf
ZURICH
Tel: 1-8433111 Tlx: 825840
Fax: 1-8433910

Syria
Far-Tou Representation
Place de l'Etoile P.O. Box 2657
29 Rue Parlement DAMASCUS
Tel: 222261, Tlx: 411319

Tanzania
International Services Ltd.
Makunganya Street
P.O. Box 5120
DAR ES SALAAM
Tel: 01-30778, Tlx: 41312

Tunisia
Tunisie Electronique Sarl
31 Avenue de la Liberté
1002 TUNIS - Belvedere
Tel: 01-280144, Tlx: 13238

Turkey
Turkelek Elektronik Co. Ltd.
Hatay Sokak 8 ANKARA
Tel: 189483, Tlx: 42120

United Arab Emirates
Scientechnic
P.O. Box 325
DUBAI
Tel: 666000, Tlx: 46072

United Kingdom
Wavetek Ltd.
Hurricane Way, Norwich
NR6 6JB, United Kingdom
Tel: 0603 404824

Venezuela
ONIMEX C.A.
P.O. Box 61421
Caracas 1062
Tel: (2) 283-7753, Fax: (2) 284-1708

Yugoslavia
Dahms Elektronik
Wienerstrasse 287
8051 GRAZ - AUSTRIA
Tel: 316-64030, Tlx: 31099

Zimbabwe
BAK Electrical Holdings Ltd.
30 Pioneer Street HARARE
Tel: 707601, Tlx: 2343

Wavetek Corporation
Instruments Division
9045 Balboa Avenue, San Diego, CA 92123
(619) 279-2200